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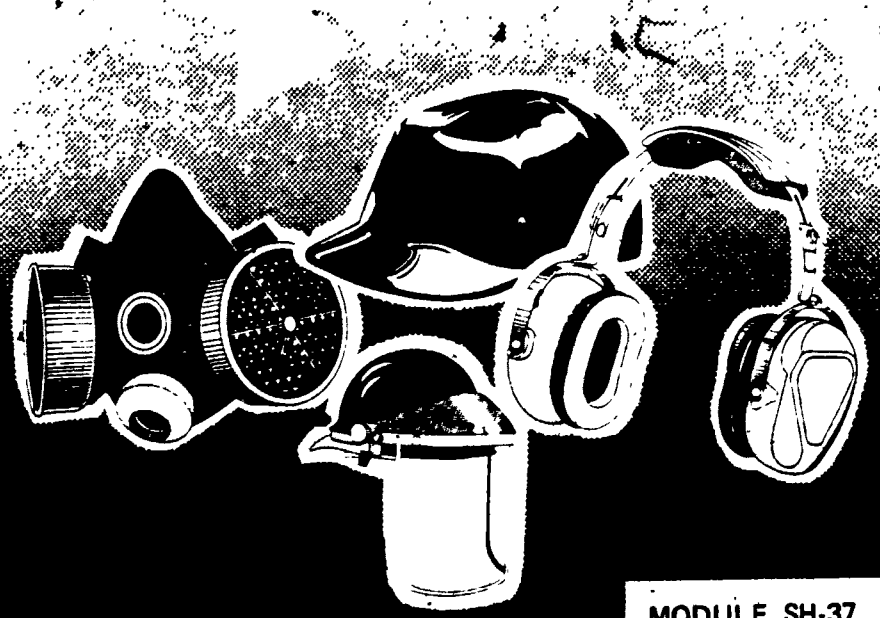
ABSTRACT

This student module on safety of concrete, forms, and shoring is one of 50 modules concerned with job safety and health. This module discusses the basic materials and chemical reactions involved in making concrete which are necessary for recognition and control of hazards. Following the introduction, nine objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., Explain safe shoring practices). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

SAFETY AND HEALTH

SAFETY OF CONCRETE,, FORMS, AND SHORING



MODULE SH-37

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INTRODUCTION

Concrete is one of the popular building materials of modern construction. It may be mixed on the job site, delivered ready-mixed, or precast. It may be used by itself or reinforced with steel. Concrete possesses great compressive strength, and when reinforced with steel, gains tensile (stretching) strength. Because concrete is used so widely, people tend to take it for granted. They forget that when working with it they are exposed to many different types of hazards. While most accidental injuries from these hazards are minor, some accidents, such as building collapse, can result in fatal injuries and high costs.

This module will discuss the basic materials and chemical reactions involved in making concrete which are necessary to recognition and control of hazards. The student will thus better understand the requirements for personal protective clothing and equipment, the use of protective creams, the need for personal cleanliness, the procedures for concrete placement during cold weather, the safe practices for shoring, and concrete in construction including slip form, tilt-up, precast, and prestressed are discussed, along with measures that should be followed to avoid injuries and extensive property damage costs.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. Identify the personal clothing, equipment, and creams used when working with concrete. (Page 3)
2. State the good housekeeping procedures and the need for personal cleanliness when working with concrete. (Page 5)
3. Describe the unique problems caused by cold weather concrete placement and list the precautions that should be taken. (Page 6)
4. Discuss requirements for reinforced steel placement in concrete forms. (Page 7)
5. Discuss handling of bulk concrete and aggregate and the importance of aggregate particle shape and size distribution. (Page 8)

6. Define and describe the requirements of nine terms associated with concrete placement. (Page 14)
7. Explain safe shoring practices. (Page 17)
8. Discuss lifting attachments, devices, and handling precautions for tilt-up construction. (Page 21)
9. State the safety factors associated with precast and prestressed concrete. (Page 23)

OBJECTIVE 1: Identify personal protective clothing, equipment, and creams used when working with cement and concrete.

An understanding of the physical and chemical properties of concrete will clarify the need for workers to wear protective clothing and to use protective cream. Concrete is a chemical mixture of cement, aggregate, water, and air. Cement is manufactured from selected raw materials that include limestone or other rock that has a high lime content. The raw materials are heated up to a temperature of 3000 degrees Fahrenheit and then ground finely, so that nearly all of them will pass through a fine sieve. Cement consitutes from 7 to 14 percent of the volume of concrete.

Aggregate, that is, sand gravel, makes up from 60 to 80 percent of the volume of concrete. The characteristics of the aggregate influence the mix portions and thus the economy of the concrete. For most uses, aggregate should consist of clean, hard, strong, durable particles, free of chemicals or coatings of clay or other fine material.

Water, which combines with the cement in the mixing process, constitutes from 15 to 20 percent of the volume of concrete. Water must be clean and free from organic materials, alkalies, acids, and oil. In general, water that is fit to drink is suitable for mixing with cement. However, water with a high sulphur content should not be used, even though it may be fit to drink, since such water combines with the cement to form a weak paste that leads to deterioration of the concrete.

Hardening of concrete is not a drying out process; rather, it is a chemical reaction. This fact can be demonstrated by placing fresh concrete under water, where it will harden despite being completely submerged. Cement and water react chemically, in a process called hydration, to form another material, cement paste, which has a useful strength. Cement paste surrounds each particle of aggregate and completely fills the spaces in between particles when the concrete is properly mixed. This chemical reaction takes about 28 days before the concrete reaches full strength.

The finely ground cement is easily carried in an air stream, and can therefore be a hazard to the eyes. Also, when cement is left on the skin it may cause a burn, dermatitis, or other skin irritation. Persons handling sacked cement should wear safety goggles; durable, close-fitting clothing with snug wrist, ankle, and neck bands; boots; and gloves. When bulk cement is handled, safety goggles and respirators must also be worn. Preferably, goggles should be the flexible fitting, regular ventilation type, similar to those shown in Figure 1. These goggles may be worn alone or over corrective spectacles. Eye and face protective equipment must be kept clean and in good repair.

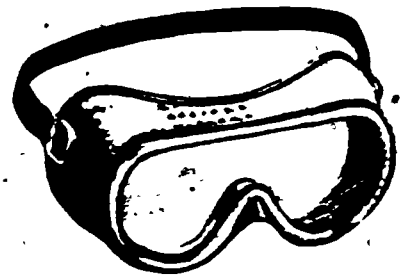

Figure 1. Flexible fitting, regular ventilation type goggles.

When working conditions are such that a person's skin is exposed to cement dust for some time, protective creams are advised. A protective cream should have a petrolatum base that provides a barrier against water-soluble alkali irritants. The cream stays on the skin for about four hours, then it may be washed off and a skin lotion applied. This type of cream and lotion may be obtained from most supply houses stocking first-aid and safety equipment.

ACTIVITY 1:*

1. List the personal protective clothing, equipment, and creams that should be used when working with cement and concrete.

a. _____
b. _____
c. _____
d. _____
e. _____
f. _____

*Answers to Activities appear on page 25.

OBJECTIVE 2: State the good housekeeping procedures and the need for personal cleanliness when working with concrete.

Good housekeeping, one of the best signs of a well-run and safe operation, is necessary on every construction job. When workers are handling concrete, good housekeeping is particularly important. Empty cement bags are covered with dust that can be blown in the air and can cause an eye injury; the bags are flammable and may easily catch fire from discarded smoking materials or from being blown into a heater or other source of ignition. Also, empty cement bags may hide hazards arising from other trash that is lying under them. For these reasons, empty cement bags should be disposed of promptly and effectively. Full cement bags must be stacked in an orderly manner to protect the cement from moisture and to facilitate removal from the storage pile without endangering employees.

Reinforcing steel and mesh that are left strewn about form a tripping hazard. A person falling on a unprotected end of either material could easily receive a puncture wound, a bad cut, or an abrasion. Forms and bracing materials should be removed and stocked piled promptly after stripping, in all areas of work or passage. Protruding nails or wire ties must be pulled or cut off to eliminate these hazards.

On well-run jobs all scrap lumber, waste material, and rubbish is removed from the immediate work area as the work progresses. Proper disposition of empty cement sacks will reduce the dust problem, but the best way to reduce cement burns, dermatitis, and skin irritation is by personal cleanliness. Frequent and thorough washing followed by the application of a protective cream or lotion is recommended.

ACTIVITY 2:

1. State the basic requirement for good housekeeping.

2. Explain the need for personal cleanliness when working with concrete: _____

_____

_____

OBJECTIVE 3: Describe the unique problems caused by cold weather concrete placement, and list precautions that should be taken.

Since concrete is used in structures and pavements because of its long life and low upkeep, an essential requirement for it is good resistance to exposure. The element that is most destructive to gaining proper strength in the setting of c[illegible]te is the freezing and thawing of water while concrete is wet or moist. The expansion of the water as it is converted into ice destroys the binding properties of the paste to the aggregate. Moisture retained in the aggregate as well as in the mix water is affected by freezing and thawing. If an aggregate particle absorbs so much water in its pore structure that an insufficient pore space is available, it will not accommodate the water expansion that occurs during freezing. The performance of a particular aggregate can be predicted by the observation of past performance or by freezing-thawing tests of concrete specimens.

Although cold weather causes problems, placing concrete does not have to be suspended during winter months if certain precautions are taken. These precautions include the use of an air-entraining agent, the preheating of aggregate and water, and if necessary, the enclosing and heating of the area. The addition of an air-entraining agent to cement during winter months is becoming increasingly popular. Entrained air is the term used for extremely small, disconnected, air bubbles that are well dispersed throughout the mass of concrete. These air bubbles allow space for the water to expand under freezing conditions, and thus prevent possible damage. A chemical additive is used to produce entrained air, and this chemical can be added to the cement during manufacture, or during the mixing stage.

If it is necessary to heat an enclosed area, care should be taken to prevent fire. Only heaters with an enclosed flame should be used, and flammable materials, including "fire resistive" tarpaulins, must not be allowed to reach the heaters. Gasoline, kerosene, and liquefied petroleum gas heaters should be attended at all times and all heaters in confined spaces must be provided with ample ventilation.

Fuel for heaters must be stored and handled using approved fuel containers, and adequate fire protection. Water hoses or fire extinguishers, must be provided adjacent to the worksite. Particular attention should be given to be sure that water systems actually will provide sufficient amounts of water to extinguish a fire. Serious fires have occurred when hoses were in place but water had not yet been made available. Ventilation and light must be also, be provided for the safety of personnel working in the enclosure.

ACTIVITY 3:

1. What purpose does air entrainment serve during cold weather concrete pouring? _____

   _____

2. Name two other procedures besides air entrainment that can be used as precautions in cold weather concrete pouring?

   a. _____

   b. _____

OBJECTIVE 4: Discuss the requirements for reinforced steel placement in concrete forms.

While weather conditions influence the strength of the concrete, the use of reinforcement steel is also extremely important due to the basic characteristics of concrete strength.

Concrete is strong in compression, but relatively weak in tension, or stretching strength. The reverse is true of slender steel bars. When the two are used together, one makes up for the deficiency of the other. When

steel is placed in concrete so that it assists in carrying the load, the combination of the two materials is called reinforced concrete. Steel used to reinforce concrete can be either bars, or welded wire fabric. Concrete reinforcing bars are available in 11 bar sizes ranging from 3/8-inch diameter to 2 1/4-inch diameter. These bars are designed with various patterns of projecting ridges called deformations (see Figure 2). These deformations allow the cement paste to bond to the bars. Welded wire fabric is another type of reinforcing steel designed with light strands of steel wire laid to form squares normally six inches by six inches. It is also available in varying diameters and is stored in rolls of four or five feet widths. Workers should use caution when unrolling welded wire rolls due to the tendency of the roll to recoil when released. The ends should be securely fastened when the roll is being transported or stored. Welded wire fabric should be unrolled and laid flat before use.

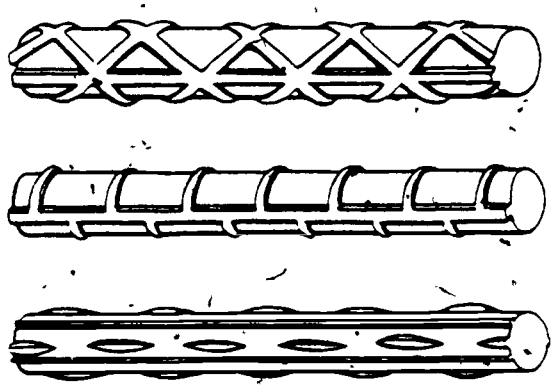

Figure 2. Steel reinforcing bars.

The correct location of the bar or wire fabric within the structure is essential to its performance. The design of concrete structures is based on years of experience and design rules published in references used by design engineers. However, the best of designs can be ruined if the design is not followed in the field. Properly reinforced concrete construction depends on workers understanding the action of the reinforced concrete and appreciating the characteristics and limitations of the material.

All steel reinforcement must be accurately located in the forms and firmly held in place before and during the casting of concrete. Concrete blocks, metallic supports (Figure 3), spacer bars, wires, or other devices may be used to ensure that the steel stays in place. An adequate number of supports or spacers should be used to support the steel as the concrete is poured, and any additional load it may have to carry. All bars should be secured to the supports and to other bars by at least 18-gage tying wire. To prevent puncture

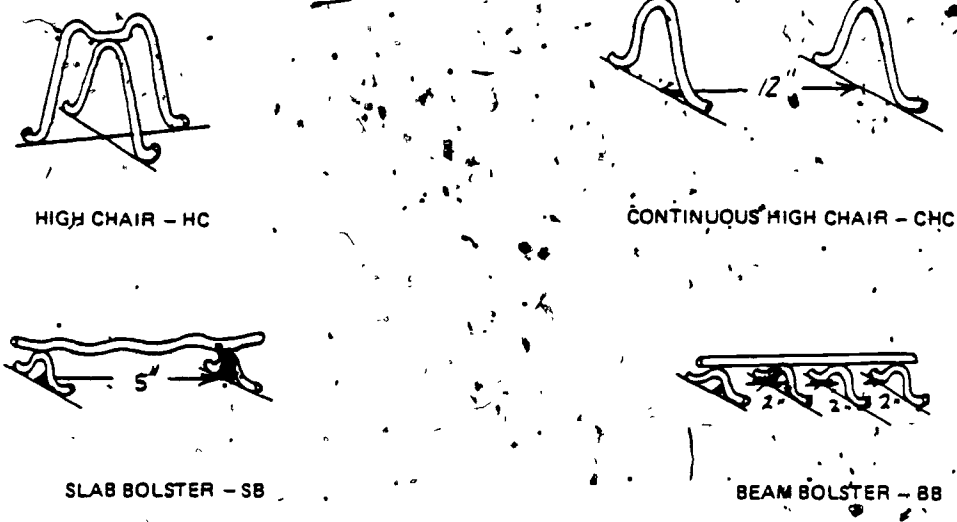

Figure 3. Supports for reinforcing steel.

wounds from the ends of the tie wire, the twisted ends should be turned to project away from interior surfaces. Other safety precautions needed when handling and installing reinforcing steel are those to prevent workers being cut, pinched, impaled, hit by steel, or falling from elevated work surfaces. The maximum possible use of material handling devices to move bulky or heavy loads of reinforcement steel can be a helpful factor in preventing injuries. When a crane is used to transport bundles of reinforcing steel, the bundles must be securely tied to prevent the load from slipping and falling. Properly spaced two-part slings must be used to balance the load when bundles over 20 feet long are being transported.

To prevent impalement, no worker should work above vertically protruding reinforcing steel without protection from the danger below. Bending the steel over or covering the protruding ends with timber or other material will protect the worker. Also, when working more than six feet above adjacent working surfaces and placing and tying reinforcing steel in walks, piers, columns, and so forth, a person must wear a safety belt. Head protection (hard hats) and eye protection should be worn when placing or tying steel, and care should be taken to provide and use safe footing over the exposed reinforcing rods. Good housekeeping is essential to reduce tripping and falling hazards.

Accidents have occurred on many jobs when vertical walls have been blown over or have otherwise collapsed. To prevent this, all reinforcing steel for walls, piers, columns, and similar structures must be guyed and supported. A "guy", is a line that steadies a vertically standing structure by pulling against an off-center load. When guying, workers must remember that reinforcing steel should not be used as guy attachments at anchorage points. Also, reinforcing steel should not be used as a load bearing member for any lifting device, and it must not be used for scaffolding hooks or stirrups.

ACTIVITY 4:

1. What purpose does steel serve when placed in concrete? _____

2. What precautions should be taken for workers working above vertically protruding reinforcing steel? _____

OBJECTIVE 5: Discuss handling of bulk concrete and aggregate and explain the importance of aggregate particle shape and size.

Safety hazards in handling and working with reinforcement steel are due largely to the size and weight of the material. Many of the hazards associated with the handling of bulk concrete and aggregate are due to these factors, but another hazard is due to the physical properties of the materials. The abrasive properties of the aggregate and the cement dust will soon wear out flimsy equipment, so equipment used to convey and to handle aggregate and cement must be designed and constructed to meet rugged demands.

Cement that is kept dry will retain its properties indefinitely. However, cement that has been stored under moist conditions sets more slowly and has less strength. Sacked cement should be stored in a dry building that is

as air-tight as possible. Sacks should be placed close together to reduce air circulation and should be kept away from outside walls. Storing for long periods necessitates covering the bags with tarpauling. If a storage building is not available, the sacks should be placed on raised wooden platforms and covered with waterproof coverings.

Cement sacks should be carefully piled and removed so that the piles will remain in a stable condition. Piles should not be more than 10 sacks high, and the end bags should be cross-piled in two separate tiers up to the fifth bag. The pile should then be stepped back one bag, and again stepped back on the 10th layer. Beginning with the fifth bag, only one cross tier is necessary. The back tier should be stepped back one bag in every five, the same as the end tiers. Cement bags in the outer tiers should be piled so that the mouths of the bags face the center of the pile. After a period of storage, cement will harden into a "warehouse pack" condition. This condition can usually be corrected by rolling the sacks on the floor.

Bulk cement can be stored for long periods in waterproof bins without deterioration. Bulk storage bins, containers, or silos should have cone-shaped or tapered bottoms with a mechanical or an air-controlled means of starting the material flow.

Selection, storage, and handling of aggregates is a more complex problem. In the selection process, the size, shape, and distribution (grading) of aggregates influences the mix portions. For example, rough-textured, flat, and elognated particles require more water for the mix to be workable. For most purposes, aggregates must be clean, hard, strong, durable, and free from clay or materials that would hinder the bonding of the cement. The particle shape and surface texture influence the properties of fresh concrete more than they affect the properties of hardened concrete. Very sharp and rough particles or flat elongated particles require finer aggregate to produce workable concrete than do particles that are more rounded or cubical. Stones that break up into long slivery pieces should be avoided.

The grading of the aggregates (particle size make-up) is important because it determines the workability, economy, ability to contain water, and the shrinkage of the concrete. The grading requirements will usually be included in the specifications for the structure being built. However, the way

the aggregate is handled and stored may change the grading. Segregation, or division, by size may be minimized by proper handling and storing (see Figures 4 and 5). Stockpiles should not be built up in a cone shape, and

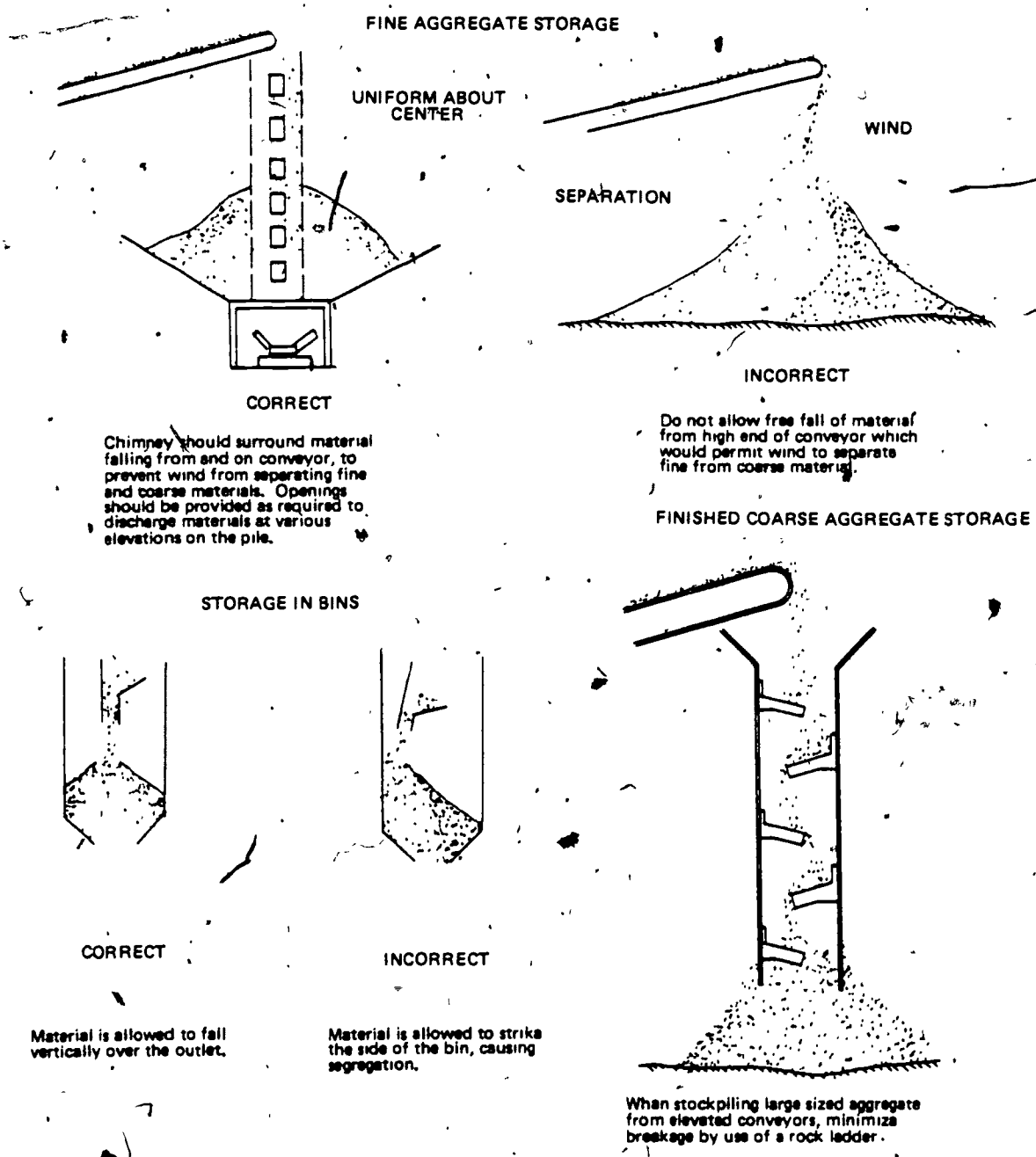

Figure 4. Correct and incorrect handling and storage of aggregates.

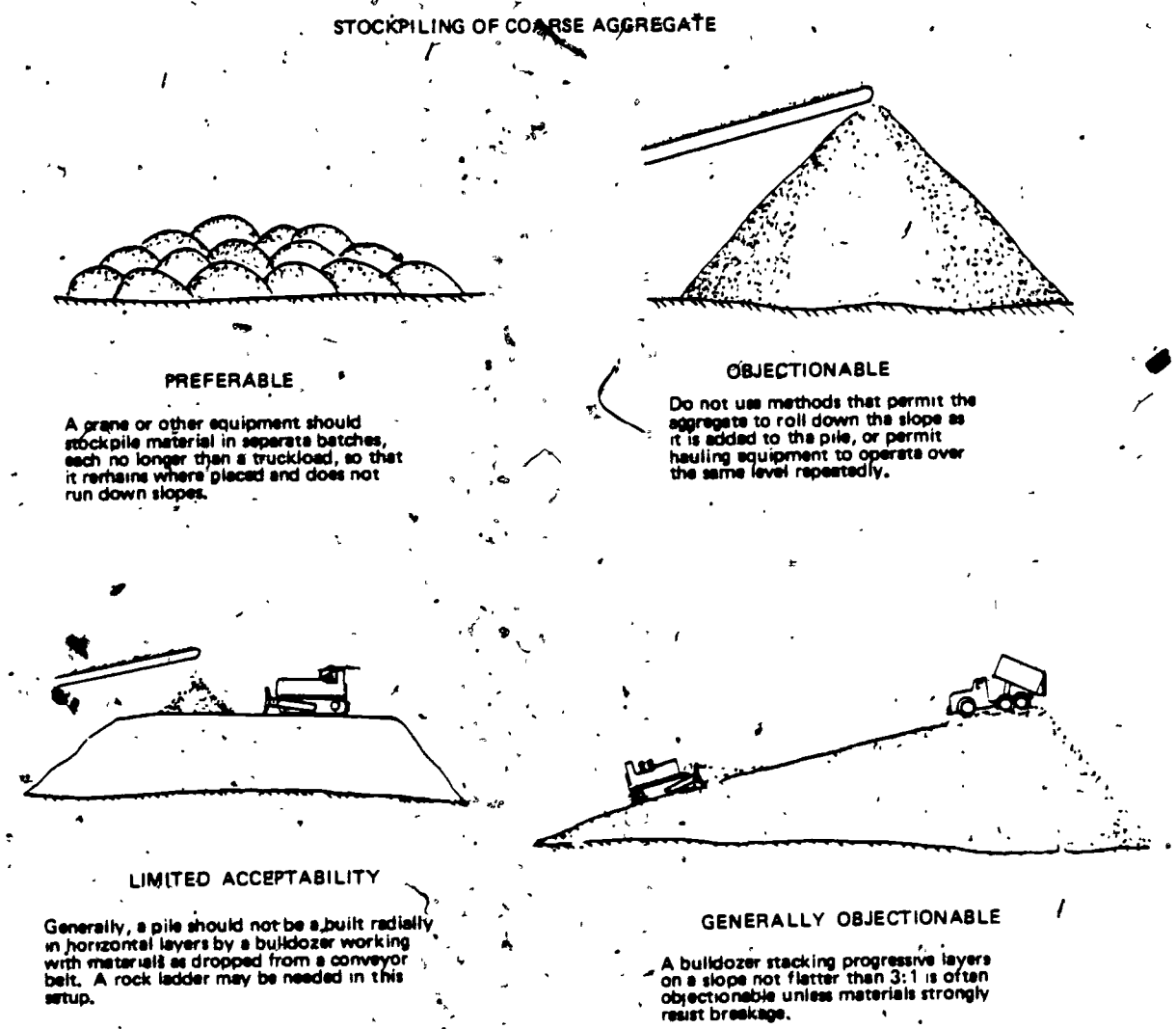

Figure 5. Stockpiling of aggregate.

aggregates should not be allowed to run down slopes. Free falling from the end of a conveyor belt will also cause segregation, so aggregates should be removed from stockpiles in approximately horizontal layers to minimize this problem. When bins are used, the bins should be loaded by allowing the material to fall vertically over the outlet. Chuting the material at an angle

against the side of the bin causes segregation of the particles. Correct and incorrect methods of handling and storing aggregates are shown in Figure 5.

ACTIVITY 5:

1. What physical properties should a good concrete aggregate have? _____

2. What properties of concrete are influenced by the particle size makeup of aggregates? _____

3. In what manner should aggregates be removed from stockpiles to minimize segregation of the aggregate? _____

OBJECTIVE 6: Define and describe the requirements of nine items associated with concrete placement.

Concrete placement requires the use of some unusual terms and tools. A short explanation of nine of these follows.

BULL FLOAT

A bull float is a hand tool that is made with a large flat blade (or face) connected to an extension handle. It is used to remove ridges and fill holes left by a straightedge, to push the aggregate beneath the surface, and to smooth slight bumps and hollows on freshly poured concrete before it has hardened. Handles on bull floats must be made of a nonconductive material, or insulated with a nonconductive sheath, when used where they may contact energized electrical conductors. The nonconductive sheath should have electrical and mechanical characteristics that provide protection equal to that of a handle made of a nonconductive material.

CONCRETE BUCKETS

A "concrete bucket" is a square or cylindrical container with a clam-shell door or gate at the bottom. Wet concrete is loaded into the concrete bucket and then lifted and swung into place, usually by a crane. Concrete buckets with gates operated either hydraulically or pneumatically should have positive safety latches or similar safety devices installed to prevent accidental dumping. Buckets are designed so as to prevent aggregate and loose material from accumulating on the top and sides.

Two safety rules should be observed around concrete buckets. First riding on concrete buckets for any purpose should be prohibited. Second, crews working the poured concrete must be kept from under the concrete bucket when it is suspended from a crane or cableway.

CONCRETE BUGGY

A "concrete buggy" is a hand cart or a motorized cart used to transport concrete from the mixer or bucket unloading area to the site where it will be placed. Handles on hand buggies should not extend beyond the wheels on either side of the buggy. Installation of knuckle guards on hand buggy handles is recommended.

DISCHARGING CONCRETE ON A SLOPE

When placing concrete on a slope, the concrete should be placed at the bottom of the slope first. Then, placing each batch against the previous one, proceed up the slope. When discharging concrete from ready-mix trucks on a slope, the truck wheels must be blocked and the brakes of the truck set in order to avoid movement.

GUARDRAILS

Guardrails are used on concrete mixers with a one yard or more capacity, to prevent persons from being caught and crushed by the skip. The skip is a loading container on the mixer that is used to carry the aggregate and cement to the drum, and is normally hoisted into position. Guardrails must be installed on both sides of the skip.

MIXERS

Concrete mixing is generally done by machine, but some hand mixing is often necessary. Hand mixing is ordinarily done on a wooden platform with either a hoe or a square-pointed shovel.

Power concrete mixers are available in many sizes and types. They are usually designated by the number of cubic feet of wet concrete the machine mixes satisfactorily in one batch. Concrete mixers equipped with one yard or larger loading skips must be equipped with a mechanical device to clean the skip of material.

Hardened concrete should not be allowed to accumulate in the mixer drum. At any time the mixer is shut down for more than one and a half hours, the drum should be cleaned by placing aggregate equal to one-half the volume of the mixer in the drum, and allowing it to revolve for about five minutes. The aggregate should then be discharged and the drum flushed out with water. The discharge chute, drum shell, or skip should not be pounded to remove hardened concrete because concrete will adhere more readily to the dents and bumps thus created.

NOZZLEMEN

"Nozzlemen" is the term traditionally used for persons who apply a cement, sand, and water mixture through a pneumatic hose. The mixture might be gunite, pumpcrete, or shotcrete. These persons are required to wear protective head and face equipment to protect against splashing or flying objects.

POWERED CONCRETE TROWELS

Powered concrete trowels are rotating-type machines used to provide a smooth surface on concrete and may be either gasoline or electrically powered.

Powered concrete troweling machines that are manually guided must be equipped with a "dead-man" control switch that will automatically shut off the power whenever the operator's hands are removed from the handles.

PUMPCRETE SYSTEMS

"Pumpcrete" systems use a heavy duty piston pump or compressed air to force concrete through a 6-, 7- or 8-inch pipeline. These pumps have a capatity of from 15 to 60 cubic yards per hour and will force concrete up to 800 feet horizontally or 100 feet vertically. These systems must have pipe supports designed for a 100 percent overload. When compressed air is used in such a system, positive fail safe joint connectors must be used to prevent separation of the sections.

ACTIVITY 6:

1. What protection should be provided for bull float handles that may come into contact with energized electrical conductors? _____

2. What is the function of a skip on a concrete mixer? _____

3. What type of control switch must a powered concrete troweling machine be equipped with? _____

OBJECTIVE 7: Explain safe shoring practices.

Shoring is the term for the system used to support concrete formwork for multiple floor structures or towers. Shoring systems may be made of tubular steel frames, timber, or adjustable wood or jack supports. In every instance, the shoring system must be designed by a qualified engineer and erected or removed only under the direction of an experienced supervisor. The failure of a shoring system, or the collapse of a concrete structure when shoring is removed too early, can cause disastrous accidents that can result in multiple fatal injuries and large property damage costs. Even though the shoring system is properly designed, erected, and supervised, persons installing or removing

shoring should understand the basic safety requirements. SAFE SHORING IS ESSENTIAL TO PREVENT THE COLLAPSE OF A CONCRETE STRUCTURE.

An accident occurred a few years ago during construction for the space mission, when a massive concrete structure collapsed during the pour. Two men were killed and 14 others injured. Investigation determined that only one piece of side bracing had not been installed as required!

The shoring design of a structure should consider all of the details and special conditions of the structure, including heavy beams, ramps, and other sloping areas, use of cantilevered slabs (slabs supported on only one end), and the method used to transport concrete to the working area. The design must also consider all foreseeable lateral loads (loads imposed from the side), such as wind, cable tensions, inclined supports, impact of placement, and the forces imposed by starting and stopping equipment. A copy of the shoring plans must be available on the job site at all times.

Shoring safety considerations must start with the foundation soil capacity and the effect weather conditions have on that capacity. For instance, a clay soil may become plastic after a rainfall, or a frozen soil may lose carrying capacity when the weather warms. If possible, soil under foundation supports should not be disturbed. If disturbance has occurred, the soil must be reworked and compacted under the direction of an engineer or other qualified individual.

Horiztonal support structures, or sills, which are used to distribute the load to the soil should be sound, rigid, and capable of carrying the load without settlement or displacement. Suitable sills should be designed for use on any floor or support where the frame legs or posts could concentrate too heavy a load or a thin concrete section.

A uniform shoring system should be used throughout the structure; adjustable wood or jack-type shoring should not be used interchangeably, or in combination, with tubular steel shoring. The reason for this is to avoid the uneven settlement that may occur when a vertical load is applied.

Before erection, all shoring equipment should be inspected to ensure that they are the type specified in the design, and are free of defects such as

cracks and excessive knots in wooden members. If tubular steel frame shoring is to be used it should be inspected for four conditions:

1. Excessive rusting.
2. Straightness of parts, no dents or kinks.
3. Damaged welds.
4. Locking devices that are in good working order; all components in condition similar to when first manufactured.

After erection, shoring equipment must be inspected just prior to concrete placement. The shoring design plan should be checked to ensure that:

1. Details of the layout, including side bracing, have been met.
2. All vertical shoring equipment is in a perfectly straight position. The maximum allowable deviation from the vertical is 1/8 inch in three feet.
3. The spacing between towers and the spacing between cross bracing is not greater than that shown on the shoring layout.
4. All locking devices are in the closed position.
5. All base plates or adjustment screws are in firm contact with the footing or sill.

Adjustments should not be made to raise the formwork after the concrete has been placed.

Constant shoring inspections should be made during concrete pouring operations to:

1. Make any corrections necessary.
2. Tighten wedges and/or adjustment screws if necessary.
3. Check for adequate protection of shoring from damage by moving vehicles or swinging loads.

Shoring and forms should not be removed too early. CONCRETE MUST BE PROPERLY SET. This can only be determined by tests on job-cured test cylinders to ensure that the concrete has attained the strength needed to carry the load. These tests are normally performed by an independent testing service that takes representative samples of the wet concrete during pouring for test purposes. Job specifications and local building codes also regulate form removal. Only persons actually engaged in the form stripping operation should be allowed in the area. Hard hats, gloves, and safety-toe shoes with heavy soles should be worn. When tie wires that hold forms together are cut, care

should be taken to avoid backlash by the tie wires. These wires might hit the body, particularly the face, eyes, and throat so the use of eye and face protection is recommended.

ACTIVITY 7:

1. Explain why shoring systems must be designed by a qualified engineer, and erected or removed only under the supervision of an experienced supervisor?

_____

_____

2. What should be included in an inspection of shoring equipment before it is erected?

a. _____
b. _____
c. _____
d. _____

3. What should be included in the inspection made just prior to concrete placement?

a. _____
b. _____
c. _____
d. _____
e. _____

4. What protective clothing or equipment should be worn when stripping forms?

a. _____
b. _____
c. _____
d. _____

OBJECTIVE 8: Discuss lifting attachments, devices, and handling precautions for tilt-up and slip form construction techniques.

Tilt-up construction is the name given to the common practice of pouring concrete wall panels adjacent to the final placing position and then tilting or lifting them into a vertical position. Often, the previously completed floor slab is used as the placing bed, and the wall section is tilted into position after curing. Each panel should be poured as close as possible to the location where it will be erected. Lifting devices and other accessories should be specified, and must not deviate from designer specifications. The panel must be cured long enough to ensure that the lifting attachment inserts are strong enough to withstand the stresses that will be placed on them during erection. Care has to be taken to prevent the panel from binding to the material against which it was poured. This can be accomplished by using a chemical compound between the base and the panel being poured. Jacks or wedges should be used to separate the cured panel from the base. Equipment shall be used so that it will not place damaging stress on the panel. Rigging equipment should be placed so the panel will not strike the boom or crane during hoisting operations (see Figure 6).

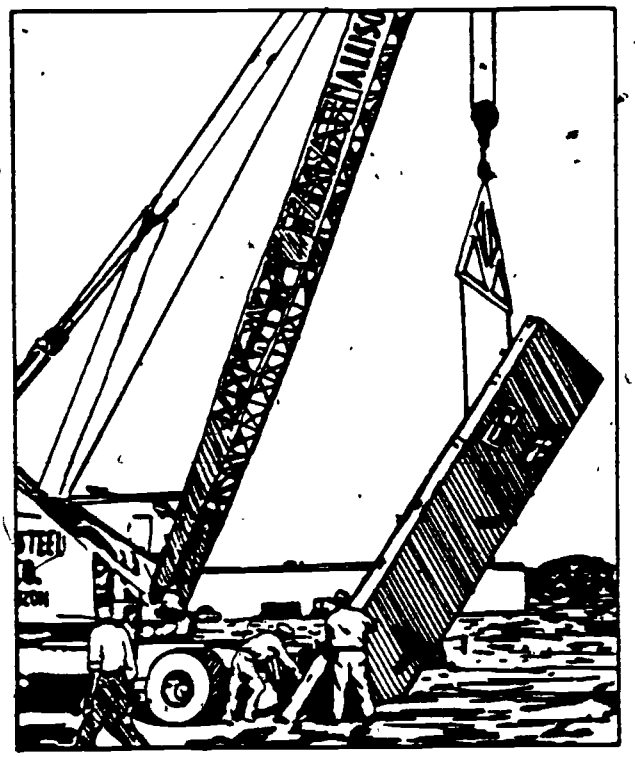

Figure 6. A tilt-up wall panel being raised into position.

Employees should never stand beneath panels or sections while they are being lifted or tilted into position.

The use of a slip form is another method of concrete placement in which lifting

devices are used. Slip forms are used as the framework for vertical structures whose design permits the continuous raising of the forms. It is an economical method because of the high rate of production allowed and the reuse of the forms.

The procedure is to pour the first layer of concrete, and wait until the concrete has attained sufficient strength to support itself and all other loads that will be imposed during the next pour. Forms are then moved up to the next level by means of hydraulic, mechanical, or air-operated jacks or lifting devices.

As in the erection of shoring, slip forms must be designed, constructed, and lifted only under the supervision of persons experienced in this technique. Engineering drawings showing the formwork, working decks, scaffolding, and jack or lifting layout must be kept available on the job site. The total area of placement must be encircled by scaffolding or work platforms to protect the workers. Lifting must proceed steadily and uniformly at a safe rate to avoid overloading at any lift points. After the forms are in place for the next pour, they should be supported by a mechanical link or stop rather than by the lifting device. Also, the forms must be braced with both lateral and diagonal bracing to prevent too great a distortion of the structure during the sliding operation.

ACTIVITY 8:

1. Who designates what lifting devices will be used on tilt-up panel construction? _____

2. What precautions are necessary with respect to rigging equipment used on tilt-up panel or slip form construction? _____

3. What precautions should workers take when panels or sections are being lifted or tilted into position? _____

OBJECTIVE 9: State the safety factors associated with precast and prestressed concrete.

Precast concrete is any concrete member that is cast in forms at a place other than the location of final use. The use of precast concrete permits rapid and economical construction. A centrally located casting plant obtains economy through stockpiling of materials and by allowing all work to be performed at ground level. This technique is used to produce beams, slabs, panels, and a wide variety of other shapes.

Casting beds range in size from a few square feet for individual components to large areas used to cast several large components at one time. Good housekeeping is essential at all times to avoid injury to the many people moving on foot throughout the area. Poor housekeeping encourages poor workmanship, and is a leading cause of accidents in the casting yard. Casting beds over three feet high should have walkways, equipped with handrails and steps, that run the entire length of the casting bed.

Heat, in the form of steam, hot water, or hot oil may be used to cure the concrete. When this is done, care must be taken to avoid burns. Piping that is not enclosed by the concrete or forms should be well insulated. All heating apparatus must be installed, maintained, and operated in compliance with the manufacturer's recommendations.

Prestressed concrete members are composed of high-strength concrete and steel. The process of prestressing is used to create very long and slender concrete structural members. The steel wires or rods are placed under high tension, and when released, place the concrete in compression. This increases the load carrying capacity, and is accomplished either by pre-tensioning or post-tensioning. When pre-tensioning is used, the steel is placed in tension before the concrete is poured. After curing of the concrete, the load is removed from the end abutments and transferred by resistance from the steel to the concrete member. When post-tensioning is used, the concrete is cast with the strands or bars enclosed in a shield and properly positioned in the form. After the concrete has set for the time required to reach specified strength, the steel is tensioned and the space remaining around the strand or bar is

filled with concrete grout pumped in under pressure. Post-tensioning is usually done from scaffolds, and there is less exposure to hazards than there is in the pre-tensioning method.

Persons who work on prestressed concrete are not only exposed to all the hazards of construction, but also to injury from the sudden unplanned release of the tremendous energy in the strands.

Prestressed concrete casting is a specialized type of operation. Every phase must be under the supervision of experienced engineers. All persons employed in the operation must be specially trained in this work and should follow all safety guidelines that are established.

ACTIVITY 9:

(Answer the following questions dealing with precast and prestressed concrete safety factors.)

1. (Mark true or false.)

   _____ Precasting of concrete is usually done away from the job site.

2. What type of access should be provided around casting beds that are over three feet high?

   _____

   _____

   _____

   _____

3. Besides exposure to usual construction hazards, persons working in prestressing operations are exposed to what special deadly hazard?

   _____

   _____

   _____

REFERENCES

American National Standard. Safety Requirements for Concrete Construction and Masonry Work, ANSI A10.9-1970. New York: American National Standard, 1970.

The Associated General Contractors of America, Inc. Manual of Accident Prevention in Construction.

U.S. Army Corps of Engineers Pamphlet. Handbook of Personal Protective Equipment, EP385-1-27.

U.S. Army Technical Manual. Concrete and Masonry, TM5-742.

U.S. Department of Labor. Occupational Safety and Health Regulations for Construction, 29 CFR 1926.

ANSWERS TO ACTIVITIES

ACTIVITY 1

1. a. Safety goggles for eye protection.
   b. Durable, close fitting clothing with snug wrist, ankle, and neck bands.
   c. Boots.
   d. Gloves.
   e. Respirators.
   f. Protective cream.

ACTIVITY 2

1. All scrap lumber, waste material and rubbish shall be removed from the immediate work area as the work progresses.
2. Frequent and thorough washing followed by application of a protective cream or lotion is recommended.

ACTIVITY 3

1. The air bubbles allow space for the water's expanding under freezing conditions and prevent possible damage to the concrete.
2. a. Preheating the aggregates and water.
   b. Enclose and preheat the area.

ACTIVITY 4

1. The steel gives the concrete tensile strength.
2. To prevent impalement, the vertically protruding steel should be bent over or the ends covered with timber or other material.

ACTIVITY 5

1. The aggregate should be clean, hard, strong, durable and free of clay, or other materials that would hinder the bonding of the cement.
2. The properties that are influenced are workability, economy, ability to contain water, and shrinkage of the concrete.
3. Aggregates should be removed in approximately horizontal layers.

ACTIVITY 6

1. The bull float handle must be made of nonconductive material or insulated with a nonconductive sheath.
2. The function of a skip is to hoist aggregate and cement to the mixing drum.
3. A "dead man" control switch that will automatically shut off the power whenever the operator's hands are removed from the handles.

ACTIVITY 7

1. The failure of a concrete shoring system, or the collapse of a concrete structure when shoring is removed too early, causes disastrous accidents that usually result in fatal injuries and always result in large property damage costs.
2. a. Freedom from excessive rusting.
   b. Straightness of parts; no dents or kinks.
   c. Undamaged welds.
   d. Locking devices that are in good working order and components that are all in condition similar to when first manufactured.
3. a. Details of the layout including lateral bracing.
   b. All vertical shoring equipment is plumb.
   c. The spacing between towers and cross bracing is not greater than that shown on the shoring layout.
   d. All locking devices are in closed position.
   e. All screws, or other extension devices, are adjusted so that base plates and shoe heads are in firm contact with the sill or form.

4. a. Hard hats.
   b. Gloves.
   c. Eye and face protection.
   d. Safety-toe shoes with heavy soles

ACTIVITY 8

1. The designer specifies lifting devices for tilt-up construction.
2. Rigging equipment should be placed so the panel will not strike the boom or crane during lifting operations.
3. Employees should not be under panels or sections.

ACTIVITY 9

1. True.
2. Walkways, equipped with handrails and steps, that run for the entire length of the casting bed.
3. Sudden release of energy if a strand breaks and whips across the work area.